Predicting Future Losses: An Introduction to Actuarial Reserving Methods

An Honors Thesis (HONR 499)

by

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Ball State University
Muncie, IN

December 2014

Expected Date of Graduation
December 2014

Abstract

Actuaries perform many roles within an insurance company. While perhaps the most notable is their work on pricing, another key responsibility is predicting future total losses. Given limited data and experience, they must be able to make estimations regarding the future costs of claims that have occurred in order for the company to keep accurate reserves. They perform this task using a multitude of actuarial models. In this paper, I will provide a brief introduction to a few of these models – namely the Loss Development, Frequency-Severity, Bornhuetter-Ferguson, and Cape Cod techniques – along with exhibits pulled from the work I performed during my internship this past summer.

Acknowledgements

I would like to thank Professor Curtis Gary Dean for his help not only on this project but also for being an exceptional teacher and resource for all actuarial science students at Ball State.

I would also like to thank my supervisor from my internship this past summer, Chad Beehler, without whom, this project would not be possible. His instruction, patience, and guidance made the learning process enjoyable and valuable.

Table of Contents

Introduction to Reserving

In the business world, financial statements must be reported on a regular and timely basis. However, in the insurance-specific world, financial liabilities can last for many years after a claim occurs. It becomes imperative that a company can accurately estimate the final costs and timing of payments for these outstanding claims. Through the use of actuarial models, a company can calculate an estimate of how much to retain in reserves. There are multiple groups that rely on these estimates, including the company itself, potential investors, and insurance regulators. Part of the role of actuaries is building and maintaining these models to ensure proper reserving is being performed. There are other benefits to this work as well, such as improved pricing accuracy and an independent review of claims department reserving practices. It will become clear that reserve modeling can quickly become complex. The purpose of this paper is to introduce the topic and demonstrate a few of the basic techniques commonly used.

Definitions

Before building or implementing any actuarial models, it is important to understand our definition of "reserve" and all liabilities which must be included in the reserve. In this paper, the term "reserve" will refer to the unpaid claim estimate. "Unpaid claim estimate" is defined in Actuarial Standard of Practice (ASOP) 43 as, "the actuary's estimate of the obligation for future payment resulting from claims due to past events" (Actuarial Standards Board, 2006). Another thing to note, the reserve is only an estimate and will vary based on the models chosen and the actuaries using them. The actual reserve amount on the books for a given company, is referred to as the "carried reserve".

The components of the reserve are "case outstanding on known claims, provision for future development on known claims, estimate for reopened claims, provision for claims incurred but not reported, and provision for claims in transit" (Friedland, 2010). The first of these components, case outstanding on known claims, is chosen by the claims adjusters on a per claim basis. Given the information to date on the claim, they estimate the future payments. The other four pieces make up a broad incurred but not reported category (IBNR). This category includes all the less predictable expenses due to the company's lack of information. Claims adjusters may not always get their case reserves correct, so those extra, unpredicted payments are accounted for in the IBNR group. When a company closes a claim, they believe that they have covered the entire cost of the loss. However, if further damage is found past closing the claim, it may have to be reopened. The specific claims incurred but not reported category refers to losses that have occurred and are covered under insurance but have not been reported to the company yet. Regardless of whether or not they are reported, the company must be prepared to make payments on those losses should they eventually be reported. Lastly, the provision for claims in transit covers losses that have occurred and been reported by the policyholder but have not been recorded by the company yet.

Table 1: Reserve Components

Component	In broad IBNR?	Description
Case outstanding on known claims	No	Estimate for expected future payments; chosen by claims adjusters on per claim basis
Future development on known claims	Yes	Extra, unpredicted payments due to adjusters' misinformation or incorrect estimation
Estimate for reopened claims	Yes	Payments for further damage found after claims have been closed
Claims incurred but not reported	Yes	Losses that have occurred and are covered by insurance, but have not been reported
Claims in transit	Yes	Losses that have occurred and are reported, but have not been recorded by the company yet

Organizational Considerations

There are a number of considerations to take into account when choosing a method of organization for the reserve model. Each claim has multiple dates of importance: policy effective date, accident date, report date, accounting date, and valuation date. Policy effective date refers to the date that coverage began for the policy the claim is covered under. Accident date is the date the loss occurred, and report date is the date the loss was reported to the company. Accounting date refers to a date for which the liability exists for a group of claims that occur on or before the accounting date. Accounting dates usually fall on the end of a month, quarter, or year. Valuation dates allow individual companies to compile data at times other than their accounting year-end. It is date that marks the cutoff for liabilities to be included in a particular group.

Table 2: Claim Dates

Date	Description
Policy effective date	Date that coverage began for policy under which the claim is covered
Accident date	Date the loss occurred
Accounting date	Date for which the liability exists for a group of claims that occur on or before the accounting date
Valuation date	Date that marks the cutoff of liabilities to be included in a particular group

Individual claims will need to be grouped by some measure in the reserve model. The most common choices are calendar year, accident year, policy year, and report year. Each has its own advantages and disadvantages which should be considered when selecting a measure. As accident year is the most commonly used by companies, it will be the measure used in all exhibits and model discussion (Friedland, 2010). However, the other methods will be discussed as well.

Friedland lists a few of the advantages of accident year aggregation as, a shorter time frame from which claims are aggregated implying a more accurate estimate sooner than those of policy year, many benchmarks by which to compare an individual company to the industry, and a better ability to track changes due to outside economic and regulatory forces. The main drawback of accident year aggregation is the variance between accident year claims and exposure measures which usually come from calendar year data.

If a company chooses to aggregate by calendar year this means that claim payments will be totaled based on the date of payment regardless of when the accident occurred. Benefits of this method can include easily attainable data and no future development. The lack of development can be considered an advantage if fixed values are desired, but most likely will be a disadvantage as many models measuring unpaid claim estimates rely on payment development patterns.

Policy year aggregation, similar to underwriting year aggregation used by reinsurers, means that claim amounts are totaled based on policy effective date. This means that claims included in one policy year can fall in a 24-month time span. For example, if a policy is effective on December 31, 2013, accidents that occur as late as December 30, 2014 are included in policy year 2013. This is a clear disadvantage of policy year aggregation as final estimates take longer to prove reliable. It is also harder to account for disruptions of large events. The major advantage is that claim payments have an exact match to exposure totals. It is also helpful if there is a major change in pricing or underwriting.

The last aggregation method is report year. It is predominantly used for special lines of business where coverage is dependent on report date instead of accident date. Friedman lists examples of medical malpractice, products liability, errors and omission, and directors' and officers' liability. The benefit of report year method is stable number of claims at the end of the year compared to accident year which can vary if claims are reported late. The major downfall is that other methods will have to be used to calculate IBNR as only known, reported claims are represented.

The actuary must also look at which types of claims are being combined in a particular model. The homogeneity and credibility of the grouped claims must be considered. Homogeneity and credibility have a positive correlation as increasing either the homogeneity or the volume of the block of data will increase credibility (Casualty Actuarial Society, 2001, p. 215). As the actuary looks at which data to combine, a common categorization is line of business. While this is generally an accepted method and is how the exhibits in this paper are done, it is important that the data be analyzed to ensure that it is of similar frequency and severity and policy limits are relatively homogeneous.

Arguably the one thing more important than the organizational method chosen is that the actuary has a complete understanding of data they are utilizing. If one has a misunderstanding of how the company or another department categorizes the complex data, any grouping the actuary does will not be completely accurate.

Development Triangles

All of our models will rely on development triangles, which organize the claims data into a format that makes it easy to manipulate and analyze as needed for individual models. As shown below, the data is sorted by accident year and amount paid in 12-month intervals. If the paid claims amount increases moving across an accident year row, this marks additional payments on those claims, or development.

Figure 1: Development Triangle

Accident Year Ending	Evaluation Age in Months									
	12	24	36	48	60	72	84	96	108	120
6/30/2005	9,316,332	12,447,466	12,841,867	12,846,568	12,870,453	12,877,208	12,877,208	12,892,208	12,892,208	12,892,208
6/30/2006	21,784,610	37,177,475	38,133,842	38,413,213	38,419,685	38,407,588	38,413,424	38,413,424	38,413,424	
6/30/2007	13,195,033	17,107,662	17,538,752	17,550,598	17,658,288	17,768,895	17,768,895	17,768,895		
6/30/2008	24,352,315	32,382,099	32,725,471	32,811,224	32,977,976	32,977,976	32,977,976			
6/30/2009	33,313,323	42,290,935	42,734,476	42,940,222	42,940,222	42,941,222				
6/30/2010	14,889,199	21,330,383	22,004,646	22,546,232	22,546,232					
6/30/2011	17,548,247	28,832,062	29,633,453	29,721,623						
6/30/2012	21,047,297	29,894,575	30,332,730							
6/30/2013	24,250,375	30,899,235								
6/30/2014	17,452,614									

The three important elements of the development triangle are the rows, diagonals, and columns. The rows each represent an accident year. The first row includes claims data, by period paid after the accident date, of all losses that occurred from 07/01/2004 to 06/30/2005, the second row includes claims data for all losses that occurred from 07/01/2005 to 06/30/2006, and so on. It has been previously noted that there are a variety of ways to categorize data, but these exhibits will all feature accident years.

The next key area is the diagonal. The diagonals represent data for other calendar year valuation dates. For example, the last diagonal, beginning with the 06/30/2014 12-month value and spanning to the 06/30/2005 120-month value, represents the valuation as of 06/30/2014. Moving one diagonal up, with values starting at the 06/30/2013 12-month value and going spanning to the 06/30/2014 108-month value, the valuation as of 06/30/2013 is represented. This pattern continues.

Lastly, there is the triangle column. It represents the age of the claims data for a given accident year. Regardless of accident year, the 12-month column represents claims amounts paid during the first year after the accident date. As the triangle uses accrued values, not incremental, the 24-month column represents the total paid on the claims in a given accident year from 0 months to 24 months after the date of loss.

Reserving Techniques

Once the actuary is familiar with the data, they can begin using individual models to determine the necessary reserve. Just as there are multiple organizational options, there are many actuarial reserving models available. Each has its own requirements and assumptions incorporated, and naturally comes with advantages and disadvantages. In the sections that follow, both the theory and process of the individual models will be discussed. Exhibits from a reserve model created in Excel will be included for further understanding.

Loss Development Technique

The loss development technique utilizes loss development triangles. This method can also be called chain ladder, which is fitting for the key assumption upon which it relies. In order for this method to provide accurate results, it must be assumed that future claim development will follow the pattern of previous claim development. Friedland (2010) also notes other assumptions of "consistent claim processing, a stable mix of types of claims, stable policy limits, and stable reinsurance retention limits throughout the experience period". Some particular models are better suited for long- or short-tail lines, but chain ladder is appropriate for all lines of business.

The process of the chain ladder begins with creating the development triangles. These were discussed previously and must be created before moving forward with the loss development technique.

The next step is calculating the development factors. These represent the change from one valuation period to another of the paid loss, case reserve, or whatever claim feature is being measured in the development triangle. As mentioned previously, examples and exhibits for this paper will be organized by accident year. For example, the development factor for paid loss for the 12 to 24 month time period of accident year 2010 would be calculated by dividing the total paid loss for accident year 2010 at 24 months by the total paid loss for accident year 2010 at 12 months. These calculations are performed on each pair of cells, working horizontally on each accident year, and are then put in a triangle of their own.

Figure 2: Development Factors

Accident Year Ending	Evaluation Age in Months									
	12	24	36	48	60	72	84	96	108	120
6/30/2005	9,316,332	12,447,466	12,841,867	12,846,568	12,870,453	12,877,208	12,877,208	12,892,208	12,892,208	12,892,208
6/30/2006	21,784,610	37,177,475	38,133,842	38,413,213	38,419,685	38,407,588	38,413,424	38,413,424	38,413,424	
6/30/2007	13,195,033	17,107,662	17,538,752	17,550,598	17,658,288	17,768,895	17,768,895	17,768,895		
6/30/2008	24,352,315	32,382,099	32,725,471	32,811,224	32,977,976	32,977,976	32,977,976			
6/30/2009	33,313,323	42,290,935	42,734,476	42,940,222	42,940,222	42,941,222				
6/30/2010	14,889,199	21,330,383	22,004,646	22,546,232	22,546,232					
6/30/2011	17,548,247	28,832,062	29,633,453	29,721,623						
6/30/2012	21,047,297	29,894,575	30,332,730							
6/30/2013	24,250,375	30,899,235								
6/30/2014	17,452,614									

Accident Year Ending	Paid Loss Development Factors								
	12 to 24	24 to 36	36 to 48	48 to 60	60 to 72	72 to 84	84 to 96	96 to 108	108 to 120
6/30/2005	1.336	1.032	1.000	1.002	1.001	1.000	1.001	1.000	1.000
6/30/2006	1.707	1.026	1.007	1.000	1.000	1.000	1.000	1.000	
6/30/2007	1.297	1.025	1.001	1.006	1.006	1.000	1.000		
6/30/2008	1.330	1.011	1.003	1.005	1.000	1.000			
6/30/2009	1.269	1.010	1.005	1.000	1.000				
6/30/2010	1.433	1.032	1.025	1.000					
6/30/2011	1.643	1.028	1.003						
6/30/2012	1.420	1.015							
6/30/2013	1.274								

Once the development factor triangles have been made, the actuary then calculates a number of averages of the factors for all accident years for each time period. Averages commonly chosen are arithmetic averages, weighted averages, and averages excluding highest and lowest values. The averages can also be calculated for a variety of history lengths. For example, the actuary might do a three-year, five-year, and all year arithmetic average in order to track pattern changes as claims data becomes more dated and possibly less reliable or claims practices less closely match those of the current day.

Figure 3: Development Factor Averages

Accident Year Ending	Paid Loss Development Factors								
	12 to 24	24 to 36	36 to 48	48 to 60	60 to 72	72 to 84	84 to 96	96 to 108	108 to 120
6/30/2005	1.336	1.032	1.000	1.002	1.001	1.000	1.001	1.000	1.000
6/30/2006	1.707	1.026	1.007	1.000	1.000	1.000	1.000	1.000	
6/30/2007	1.297	1.025	1.001	1.006	1.006	1.000	1.000		
6/30/2008	1.330	1.011	1.003	1.005	1.000	1.000			
6/30/2009	1.269	1.010	1.005	1.000	1.000				
6/30/2010	1.433	1.032	1.025	1.000					
6/30/2011	1.643	1.028	1.003						
6/30/2012	1.420	1.015							
6/30/2013	1.274								
All Year Average	1.412	1.022	1.006	1.002	1.001	1.000	1.000	1.000	1.000
All Year Weight	1.404	1.020	1.006	1.002	1.001	1.000	1.000	1.000	1.000
All Year (ex hi/lo)	1.390	1.023	1.004	1.002	1.000	1.000	1.000		
5 Year Average	1.408	1.019	1.007	1.002	1.001				
5 Year Weight	1.380	1.017	1.006	1.002	1.001				
5 Year (ex hi/lo)	1.364	1.018	1.003	1.002	1.000				
3 Year Average	1.446	1.025	1.011	1.002	1.002	1.000	1.000		
3 Year Weight	1.426	1.024	1.009	1.002	1.001	1.000	1.000		

After calculating the averages, the next step is to select one development factor for each period, i.e. 12 to 24 months, 24 to 36 months, etc., based on the calculated averages. Casualty Actuarial Society (2001) notes that it is important to recognize the averages are only helpful guides. The actuary must exercise their judgment and use all the available resources to make manual selections. This is where having a complete understanding of changes in company structure or knowledge of particularly abnormal years is beneficial. This step involves a lot of analysis in order to provide trustworthy results. If the actuary observes changes in patterns, they must be able to determine if the changes are most likely an isolated occurrence or should be expected to continue in the future. Ultimately, these selected development factors are made by real actuaries because they can usually make better estimates than computers by considering all factors involved.

Figure 4: Selected Development Factors

	12 to 24	24 to 36	36 to 48	48 to 60	60 to 72	72 to 84	84 to 96	96 to 108	108 to 120	Tail Factor
All Year Average	1.412	1.022	1.006	1.002	1.001	1.000	1.000	1 000	1.000	
All Year Weight	1.404	1.020	1.006	1.002	1.001	1.000	1.000	1 000	1.000	
All Year (ex hi/lo)	1.390	1.023	1.004	1.002	1.000	1.000	1.000			
5 Year Average	1.408	1.019	1.007	1.002	1.001					
5 Year Weight	1.380	1.017	1.006	1.002	1.001					
5 Year (ex hi/lo)	1.364	1.018	1.003	1.002	1.000					
3 Year Average	1.446	1.025	1.011	1.002	1.002	1.000	1.000			
3 Year Weight	1.426	1.024	1.009	1.002	1.001	1.000	1.000			
Selected	1.400	1.020	1.005	1.002	1.001	1.000	1.000	1.000	1.000	1.000

There is also a tail factor in the previous exhibit. Hopefully, the actuary will have enough data available so that the oldest development factors have approached one, meaning that claim development has stabilized and there are no longer additional payments being made. Thus, the tail factor, representing all payments beyond the time frame chosen for the model, will also be one. However, sometimes this is not true due to lines of business with long tails or a lack of data. In these cases, special care must be taken when choosing a tail factor as it will apply to all accident years in the model. Friedland (2010) notes that using industry benchmarks or fitting a curve to the other selected development factors are possible methods to improve accuracy.

Next, the actuary will use the selected age-to-age development factors to determine the age-to-ultimate, or cumulative claim, development factors. The age-to-ultimate factors are calculated by multiplying the relevant age-to-age factors together. The age-to-ultimate factor for 120 months-to-ultimate is simply the tail factor. The 108-to-120 age-to-ultimate factor is the tail factor multiplied by the age-to age factor for 108-to-120. This process continues through the 12-to-24 age-to-ultimate factor, which is found by multiplying all selected development factors together.

Figure 5: Age-to-Ultimate Factors

	12 to 24	24 to 36	36 to 48	48 to 60	60 to 72	72 to 84	84 to 96	96 to 108	108 to 120	Tail Factor
Selected	1.400	1.020	1 005	1.002	1.001	1 000	1.000	1 000	1.000	1.000
Age to Ultimate	1.439	1.028	1.008	1.003	1.001	1.000	1.000	1.000	1.000	1.000

The last step is to finally predict the ultimate claim amounts. Age-to-ultimate factors are the factors that the total paid as of the valuation date should be multiplied by in order to determine the final, ultimate cost of the claims that occurred in that accident year. So in Figure 6 below, each of values in the last diagonal of the triangle is multiplied by the corresponding age-to-ultimate factor below it. For example, for year 2014, 17,452,614 is multiplied by 1.439 to equal 25,122,135.

Figure 6: Final Ultimates

Accident Year Ending	Evaluation Age in Months										Final Yearly Ultimate
	12	24	36	48	60	72	84	96	108	120	
6/30/2005	9,316,332	12,447,466	12,841,867	12,846,568	12,870,453	12,877,208	12,877,208	12,892,208	12,892,208	12,892,208	12,892,208
6/30/2006	21,784,610	37,177,475	38,133,842	38,413,213	38,419,685	38,407,588	38,413,424	38,413,424	38,413,424		38,413,424
6/30/2007	13,195,033	17,107,862	17,538,752	17,550,598	17,658,288	17,768,895	17,768,895	17,768,895			17,768,895
6/30/2008	24,352,315	32,382,099	32,725,471	32,811,224	32,977,976	32,977,976	32,977,976				32,977,976
6/30/2009	33,313,323	42,290,935	42,734,476	42,940,222	42,940,222	42,941,222					42,941,222
6/30/2010	14,889,199	21,330,383	22,004,646	22,546,232	22,546,232						22,568,778
6/30/2011	17,548,247	28,832,062	29,633,453	29,721,623							29,810,848
6/30/2012	21,047,297	29,894,575	30,332,730								30,575,908
6/30/2013	24,250,375	30,899,235									31,769,893
6/30/2014	17,452,614										25,122,135
Age to Ultimate	1.439	1.028	1.008	1.003	1.001	1.000	1.000	1.000	1.000	1.000	

These results represent the expected ultimate claims, or how much the claims for the given period will cost at the end of their life. To calculate the IBNR, one simply subtracts the total paid-to-date from the expected ultimate. Friedland notes that IBNR amounts should generally increase moving towards the most recent periods.

The necessary assumptions were mentioned previously, however, it is important to reiterate them. The major requirement is a stable claims processing environment, meaning regular reserves set on individual claims, regular payment and claim closing speeds, and little change to reinsurance limits. The need for a large claims history makes this technique less accurate on newer lines of business. High-frequency, low-severity lines of business with claims spread throughout the year work very well with this model. When it comes to the tail length of a given line of business, long-tailed lines ultimate estimates will be highly sensitive to the development factors chosen. This is because the older development factors often don't reach one and can even be as high as 10 (Friedland, 2010).

Frequency-Severity Technique

A second model that can be used is the frequency-severity model. There are multiple approaches that can be applied for this model, but only one will be focused on here. This approach is heavily based on the loss development technique previously described, however, the frequency and severity portions are split apart in order to find a more accurate estimate when a change in claims processing or management has occurred. By breaking the claims ultimate into the two pieces, the actuary can look at individual trends before combining them again.

The key assumption associated with this technique is that claim counts are homogeneous and consistently grouped. An example of inconsistent grouping noted by Friedman is a claimants count versus an occurrence count. A lack of homogeneity in claims, like small property damage claims being mixed in with very large lawsuit claims, will lead to an unreliable severity average. As mentioned, this process will rely on the development process, meaning its assumptions apply here as well.

The process begins with the creation of more triangles. This time, instead of claims totals, they will feature claims counts for the frequency portion and average claim totals for the severity portion. The claims counts triangle should be cumulative, not incremental, just as the claims totals were. The average claim total triangle can be found by taking the claims totals triangle and dividing each cell of the triangle by the corresponding cell in the claims counts triangle.

Figure 7: Frequency Development Triangle

Accident Year Ending	Evaluation Age in Months										Yearly Ultimate
	12	24	36	48	60	72	84	96	108	120	
6/30/2005	2,286	2,451	2,482	2,481	2,486	2,491	2,490	2.488	2,489	2489	2,489
6/30/2006	3,188	3,384	3,384	3,382	3,368	3,394	3,392	3.390	3,391		3,391
6/30/2007	3,158	3,375	3,941	3,950	3,958	3,957	3,957	3,957			3,957
6/30/2008	2,984	3,120	3,141	3,148	3,149	3,149	3,150				3.150
6/30/2009	3,347	3,398	3,402	3,412	3,412	3414					3,414
6/30/2010	3,782	3,847	3,851	3,855	3,856						3,856
6/30/2011	3,476	4,046	4 069	4,071							4,075
6/30/2012	2,978	3,597	3,615								3,626
6/30/2013	3,219	3,584									3,613
6/30/2014	2977										3451

Figure 8: Severity Development Triangle

Accident Year Ending	Evaluation Age in Months										Yearly Severity Ultimate
	12	24	36	48	60	72	84	96	108	120	
6/30/2005	5,016	5,275	5,239	5,178	5.177	5,174	5,178	5.182	5,180	5.180	5.180
6/30/2006	8,749	11,230	11.340	11,361	11,340	11.316	11,325	11,331	11,328		11,328
6/30/2007	5218	5,262	4,489	4,483	4488	4.490	4,490	4,490			4490
6/30/2008	9.798	10,617	10,470	10,449	10,473	10.473	10,469				10,469
6/30/2009	11.550	12,605	12,627	12,585	12,585	12,578					12,578
6/30/2010	5.004	5,667	5.860	5,850	5,860						5,860
6/30/2011	6,529	7,223	7,299	7,322							7,322
6/30/2012	7.914	8,455	8,459								8,468
6/30/2013	9,333	8,792									8,933
6/30/2014	8019										8473

Once the triangles are made for each of the pieces, the actuary selects development factors for each separate piece, just as they did in the loss development process. This will result in two projected ultimates – frequency and severity. To find the total expected ultimate claims for each year, simply multiply the ultimates together for the respective periods.

Frequency-Severity models can help enhance the actuary's final estimate by allowing them to look further at trends within individual pieces of the claims data. Changes in the claims processes can be more easily tracked and accounted for. It is particularly helpful when looking at the latest accident years, where the regular loss development technique can have more variation. As with all the models, there are drawbacks to the Frequency-Severity technique that need to be mentioned as well. If the actuary does not have all the individual pieces of data available, it might not be possible to use. Also, a company can easily change its definition of a claim over long periods of time, meaning that the data may not always be consistent. Friedman notes that these changes may come from the company or even external sources such as, "changes in the waiting periods, statutes of limitation, and no-fault coverage" (Friedman, 2009). Any abnormal events that may cause a change in the frequency or severity patterns may cause problems too. An event that causes a high frequency of claims of low severity, may disrupt the patterns.

Bornhuetter-Ferguson Technique

The next model is a little different from the previous two, but does share a few root assumptions. Named after Ronald Bornhuetter and Ronald Ferguson, the method is based on the pair's 1972 paper "The Actuary and IBNR" (Bornhuetter & Ferguson, 1972). The technique looks at the actual paid amounts as well as the expected unpaid claims. As accident years move farther from the valuation date, the actual amounts are weighted higher than the expected amounts.

With the loss development technique, the IBNR is found under the assumption that development will follow that of what has been reported so far. Bornhuetter-Ferguson differs in that it assumes IBNR will be based on expected claims (Friedland, 2010). While the method uses the same development factors found previously, they are applied in a different way.

The method can be applied with short-tail or long-tail lines. While it normally is used for reported or paid claims, it can also be used for other measures like claim counts or adjusting expenses. As is true with most models, the actuary can organize the data in a variety of ways. Once again, the process will be outlined using accident year aggregation.

To begin this method, the actuary needs to have an expected claims number. (Some reserving manuals group this as a separate technique, but for the purposes of this paper, it will be considered the first step of the Bornhuetter-Ferguson process.) This is a fairly simple step. The actuary must pick a loss ratio for each period using their best judgment of previous results. These loss ratios indicate the percentage of the total premiums are expected to go towards paying losses. So, to find the expected claims, simply take the total premiums for the period and multiply by the corresponding loss ratio.

Next, it is important to find how much of the expected total loss has already occurred and how much is yet to happen. This can be done using the same development factors from the Loss Development technique. The ratio of cumulative paid loss to total loss can be found by inverting the cumulative development factors for each period. One minus this ratio naturally represents the ratio of undeveloped paid loss to total loss. This last ratio can be multiplied by the expected total loss number calculated before to find the expected amount left to pay, or the IBNR. Adding this amount to what has already been paid per period will give you the total expected ultimate loss.

Figure 9: Bornhuetter-Ferguson Technique

Accident Year Ending	Ultimate Premiums	Selected Loss Ratio	Expected Ultimate Loss	Selected Development Factors	Cumulative Development Factors	Ratio of Cumulative Paid Loss to Ultimate Loss	Ratio of Undeveloped Paid Loss to Ultimate Loss	Undeveloped Paid Loss	Cumulative Paid Loss	Ultimate Loss
6/30/2005	26,324,011	0 600	15,794,407	1.000	1 000	1.000	0.000	0	12.892,208	12.892.208
6/30/2006	27,957.290	0.610	17,053,947	1.000	1.000	1.000	0.000	0	38,413.424	38,413,424
6/30/2007	29,863,535	0 620	18.515,391	1.000	1.000	1 000	0.000	0	17,768,895	17.768.895
6/30/2008	32,834,528	0.630	20.685,753	1.000	1.000	1.000	0.000	0	32.977.976	32.977.976
6/30/2009	36,688,523	0.640	23,480,655	1.000	1 000	1 000	0 000	0	42.941,222	42,941,222
6/30/2010	40,255,443	0 650	26,166,038	1.001	1 001	0.999	0 001	26 140	22,546,232	22,572.372
6/30/2011	39,704,736	0.660	26205,126	1.002	1 003	0.997	0.003	78.432	29,721,623	29.800.056
6/30/2012	38,801,736	0.670	25.997,163	1.005	1.007	0.993	0.007	180,972	30,332,730	30,513,702
6/30/2013	40,324,727	0 680	27,420.814	1.020	1.025	0.976	0 024	671.410	30.899,235	31 570 645
6/30/2014	44,347,210	0.690	30,599,575	1.400	1 428	0 700	0.300	9,171,301	17,452,614	26 623.915
Total	357,101,738		231.918,868					10,128,255	275 946 159	286,074 414

The downside to this method is that it relies very heavily on the manually selected loss ratios. This means the actuary will need to exercise great caution when choosing them. Friedland notes that this is a good fit for long-tail lines, “particularly for the most immature years, due to the highly leverage nature of claim development for such lines”. New lines of business or other lines, like umbrellas, with sparse or volatile data can also be a good fit for this technique. As always, with small amounts of data, the industry benchmarks should be referenced for extra support.

Cape Cod Technique

The final technique that will discussed here is Cape Cod. This method can also be called Stanard-Buhlmann. The Cape Cod resembles the Bornhuetter-Ferguson method in a lot of ways and pulls some information from it, but differs in how the expected loss ratios are chosen. While Bornhuetter-Ferguson relies mostly on judgment, Cape Cod uses claims experience. Here we assume, as we did with Bornhuetter-Ferguson, future development will be based on expected claims. The method can be used on both short and long tailed lines. It is commonly used by reinsurers.

As mentioned, the variation between Cape Cod and Bornhuetter-Ferguson is with the loss ratios applied to the earned premium. Instead of manually selecting loss ratios, now, the loss ratio will be calculated by dividing the expected claim total from all accident years from the Bornhuetter-Ferguson method by the total earned premium for all accident years. (The 0.801 in *Figure 10* below is found by dividing 286,074,414 from *Figure 9* by 357,101,738.) After this slight alteration, the rest of the process is the same as before.

Figure 10: Cape Cod Technique

Accident Year Ending	Earned Premium	Selected Loss Ratio	Expected Ultimate Loss	Selected Development Factors	Cumulative Development Factors	Ratio of Cumulative Paid Loss to Ultimate Loss	Ratio of Undeveloped Paid Loss to Ultimate Loss	Undeveloped Paid Loss	Cumulative Paid Loss	Ultimate Loss
6/30/2005	26,324,011	0.801	21 088,181	1.000	1.000	1.000	0.000	0	12.892,208	12.892.208
6/30/2006	27,957,290	0.801	22,396,601	1.000	1.000	1 000	0.000	0	38,413.424	38,413,424
6/30/2007	29,863,535	0.801	23,923,695	1 000	1.000	1.000	0.000	0	17,768,895	17.768.895
6/30/2008	32,834,528	0.801	26,303.760	1.000	1.000	1.000	0.000	0	32,977.976	32.977,976
6/30/2009	36,688,523	0.801	29.391,197	1.000	1.000	1.000	0.000	0	42,941 222	42,941,222
6/30/2010	40,255,443	0.801	32,248.659	1.001	1.001	0.999	0.001	32 216	22,546.232	22 578,449
6/30/2011	39,704,736	0 801	31,807,486	1.002	1.003	0.997	0.003	95 200	29.721,623	29,816.823
6/30/2012	38,801,736	0 801	31.084,093	1 005	1.007	0.993	0 007	216,383	30.332,730	30,549.113
6/30/2013	40,324,727	0.801	32,304.153	1.020	1.025	0.976	0 024	790 981	30.899,235	31.690.216
6/30/2014	44,347,210	0.801	35 526,576	1 400	1 428	0.700	0 300	10.648,022	17,452.614	28.100 635
Total	357,101,738		286 074,414					11.782.802	275,946 159	287,728,961

While Bornhuetter-Ferguson is good to use with thin or volatile data, Cape Cod is a little less reliable. This is because the loss ratio is calculated using the expected claims totals, which must have a decent amount of data to produce an accurate total.

Conclusion

Once the actuary has a variety of models with ultimate loss estimates completed, they need to do a side-by-side comparison for each line of business or division they may be utilizing. The actuary doesn't necessarily have to choose an exact result from one model but can instead, choose any final selection they see fit, taking into account each model's results and the assumptions and specifications that go along with the results. As mentioned at the beginning of this paper, any model's results are only an estimate. It still remains of great importance for the actuary to analyze the whole situation in order to come to the well thought out suggestion.

Figure 11: Model Summary

Accident Year Ending	Earned Premium	Paid	Case	Reported	Estimated Ultimates				Final Selected Ultimate	Indicated IBNR
					Loss Development	Bornhuetter-Ferguson	Cape Cod	Frequency/ Severity		
6/30/2005	26,324,011	12,892,208	0	12,892,208	12,892,208	12,892,208	12,892,208	12,892,208	12,892,208	0
6/30/2006	27,957,290	38,413,424	0	38,413,424	38,413,424	38,413,424	38,413,424	38,413,424	38,413,424	0
6/30/2007	29,863,535	17,768,895	0	17,768,895	17,768,895	17,768,895	17,768,895	17,768,895	17,768,895	0
6/30/2008	32,834,528	32,977,976	0	32,977,976	32,977,976	32,977,976	32,977,976	32,977,976	32,977,976	0
6/30/2009	36,688,523	42,941,222	0	42,941,222	42,941,222	42,941,222	42,941,222	42,941,222	42,941,222	0
6/30/2010	40,255,443	22,546,232	50,003	22,596,235	22,568,778	22,572,372	22,578,385	22,596,235	22,600,813	4,578
6/30/2011	39,704,736	29,721,623	87,215	29,808,838	29,810,848	29,798,867	29,816,635	29,838,647	29,820,000	11,162
6/30/2012	38,801,736	30,332,730	247,518	30,580,248	30,575,908	30,508,300	30,548,683	30,702,722	30,610,000	29,752
6/30/2013	40,324,727	30,899,235	610,535	31,509,770	31,769,893	31,541,024	31,688,646	32,271,058	31,605,000	95,230
6/30/2014	44,347,210	17,452,614	6,420,213	23,872,827	25,122,135	26,092,246	28,079,498	29,241,727	26,929,144	3,056,317
	357,101,738	275,946,159	7,415,483	283,361,642	284,841,287	285,506,533	287,705,571	289,644,113	286,558,681	3,197,039

There are a few important notes to conclude with. Being able to see the whole picture requires the actuary to be in regular communication with both underwriting and claims departments. This insures that they will have a thorough understanding of not only how the claims, premium, and policy count data are structured, but also will be knowledgeable about any large changes in organizational processes.

These are only a few of the possible models that actuary can use. Regardless of which they choose, multiple need to be chosen to provide a variety of results. Once these numbers are chosen, the actuary's work is not done. The process will need to be performed on most likely a monthly, quarterly, or yearly basis, depending on the company or line of business. Results and new data will need to be monitored to ensure the models are working accurately.

Actuaries provide many services for insurance companies. Loss reserving is one of those important services. With careful judgment and a great background knowledge, the actuary can provide good estimates for final claims costs to company managers, investors, and regulators alike.

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